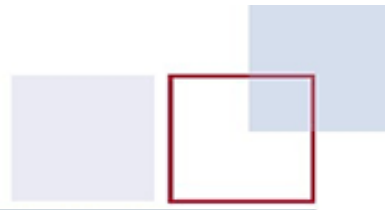


# Statistics



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Ph.D. in Biostatistics

# What is in this workshop

- Basics of Statistics
- How to use SPSS
- How to get descriptive statistics
- How to get inferential statistics

# Statistics

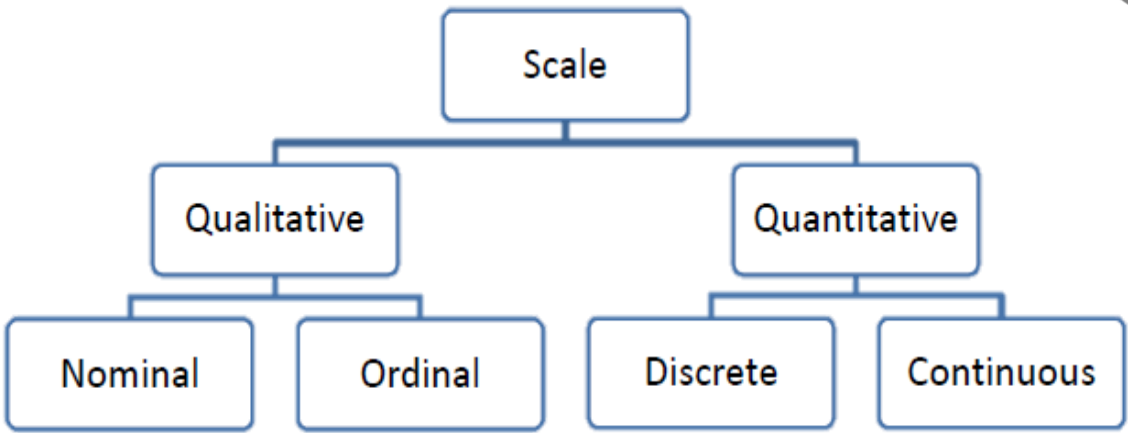
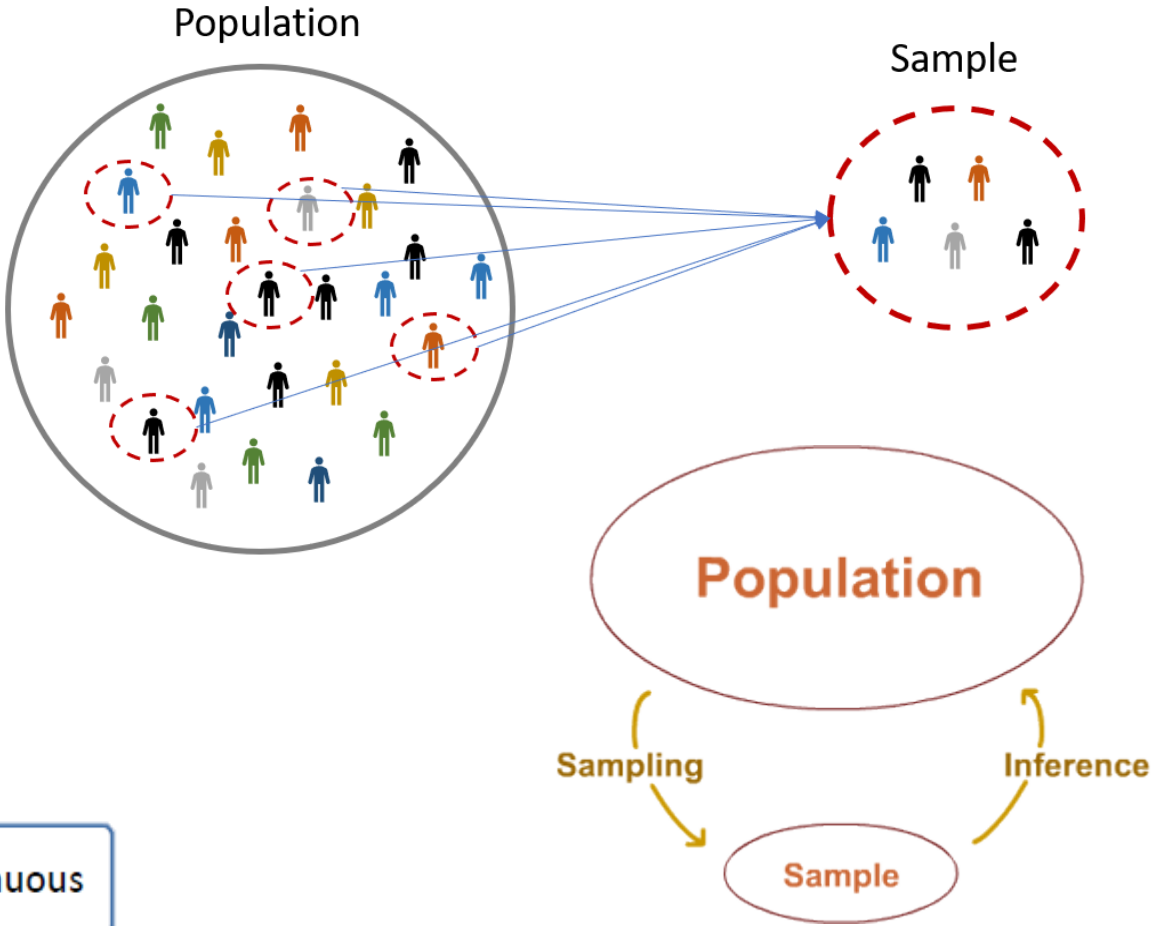
- The science of collection, organization, summarize, analysis, interpretation of data.

# Two areas of statistics:

- **Descriptive statistics**  
(which summarize some characteristic of a sample)
- **Inferential statistics**  
(which test for significant differences between groups and/or significant relationships among variables within the sample)

# Basic Terms

- Population
- Sample
- Variables

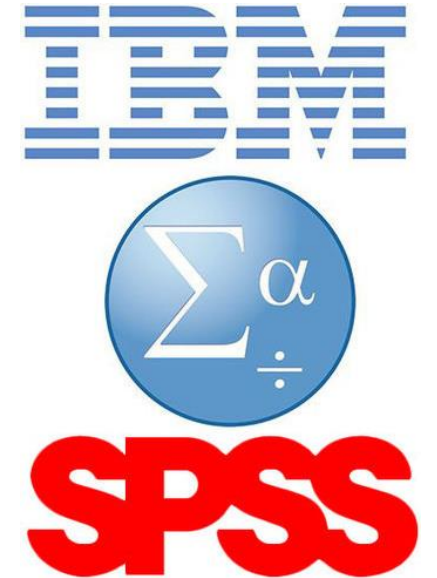


# Data Analytics Tools



# What is SPSS ?

- SPSS stands for Statistical Package for the Social Sciences
- SPSS was made to be easier to use than other statistical software like S-Plus, R, or SAS.
- The newest version of SPSS is SPSS 26.0.



# Uses for SPSS

- Data management
  - Defining variables
  - Coding values
  - Entering and editing data
  - Creating new variables
  - Recoding variables
  - Selecting cases
- Data analysis



# How to open SPSS

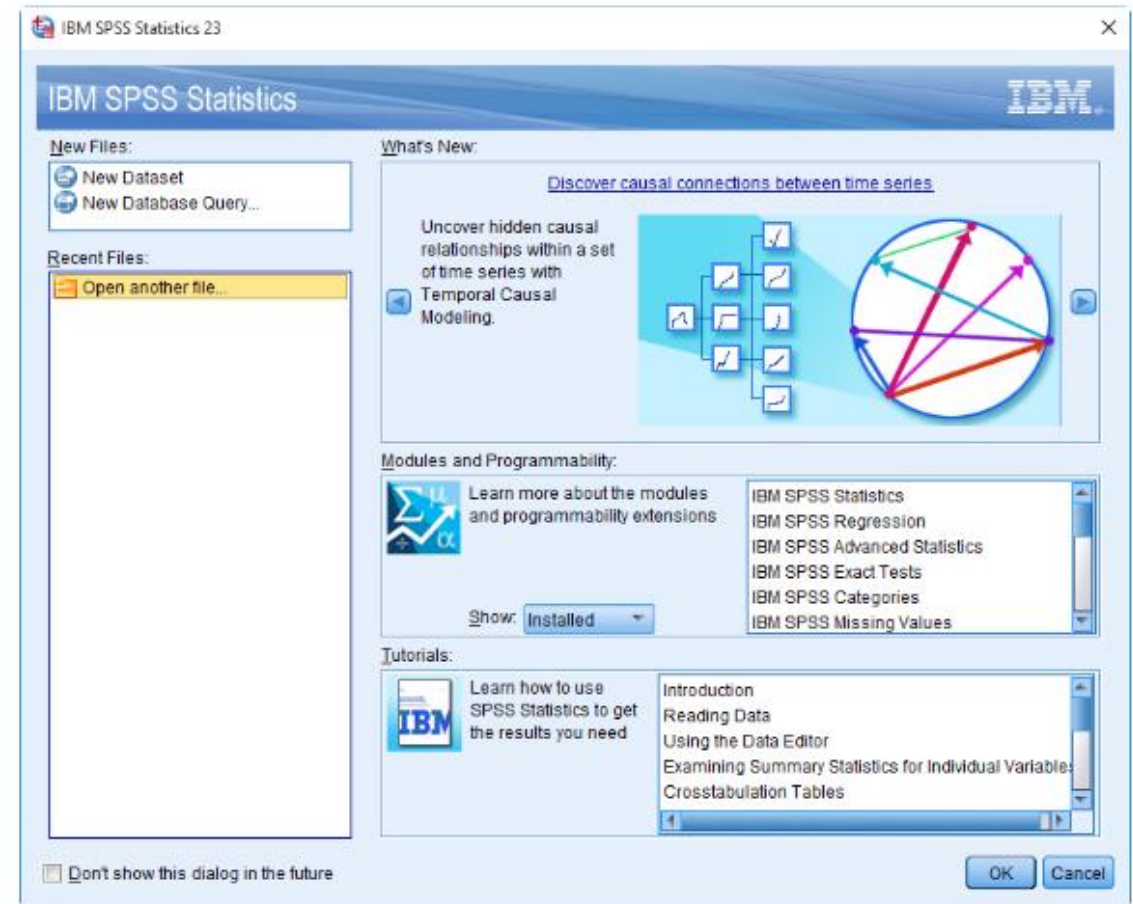
Double click the SPSS icon on the desktop

Start  
Menu

Programs

SPSS for  
windows

SPSS



# The two main windows



# Data editor

This screenshot shows the IBM SPSS Statistics Data Editor in Data View. The interface includes a title bar, a menu bar, and a toolbar. The main area is a grid with rows representing cases and columns representing variables. Annotations with arrows point to various components:

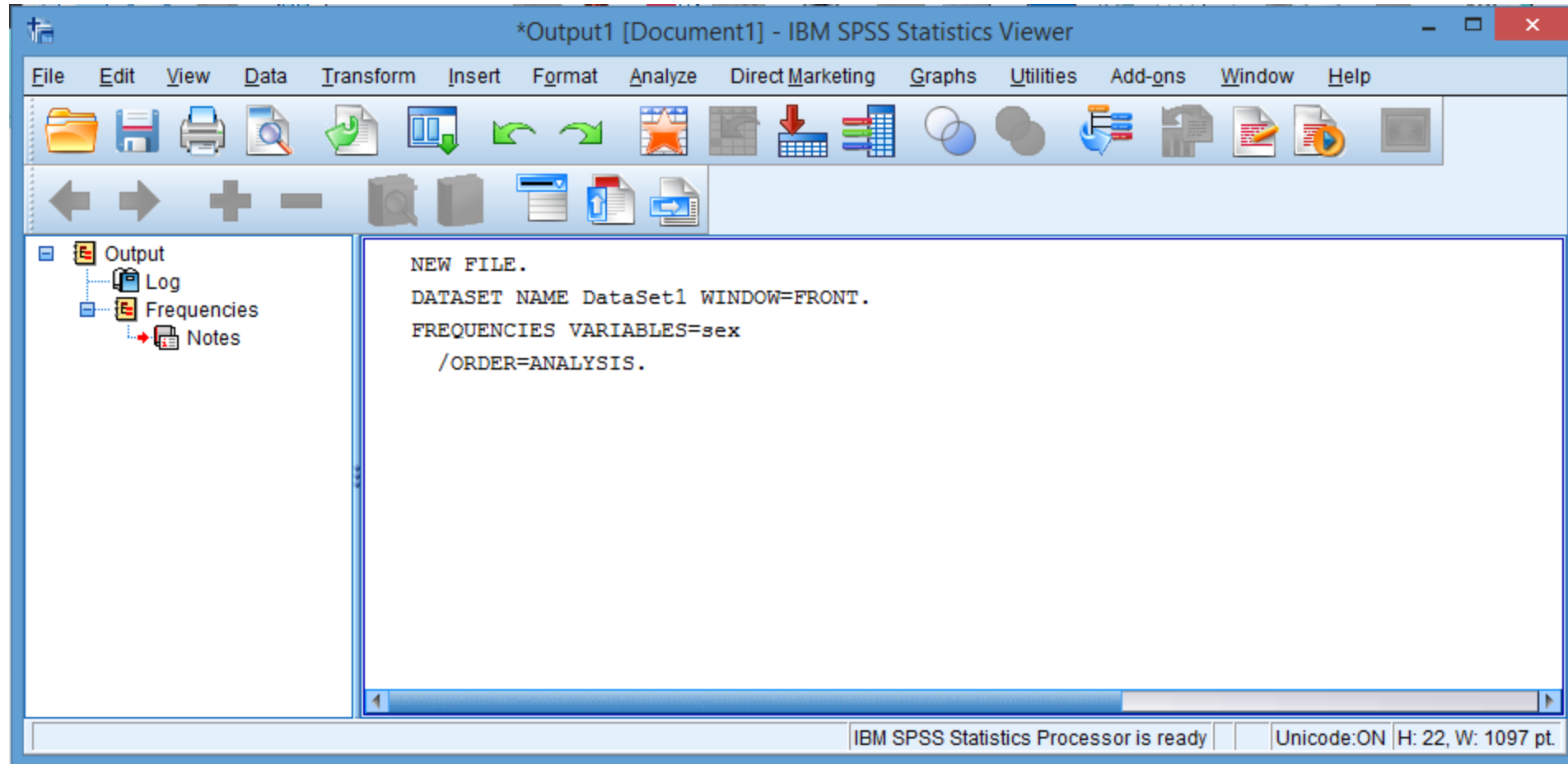
- Title Bar:** Points to the window title "Untitled2 [DataSet1] - IBM SPSS Statistics Data Editor".
- Data Editor Toolbar:** Points to the toolbar containing icons for file operations, editing, and analysis.
- Menu Bar:** Points to the menu bar with options: File, Edit, View, Data, Transform, Analyze, Direct Marketing, Graphs, Utilities, Add-ons.
- variable:** Points to a column header labeled "var" in the variable list.
- Case:** Points to the row number "3" in the case list.
- Cell:** Points to an empty cell in the data grid.
- Data View Tab:** Points to the "Data View" tab at the bottom.
- Variable View Tab:** Points to the "Variable View" tab at the bottom.

Case	var	var	var	var	var	var	var	var
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								

This screenshot shows the IBM SPSS Statistics Data Editor in Variable View. The interface is similar to the Data View, but the main area is a table defining the properties of the variables.

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									

# Output viewer



# Descriptive statistics

- ❑ Collection
- ❑ Organization
- ❑ Summarize data
  - Tables
  - Graphs
  - Measures of Central Tendency
  - Index of dispersion

# Example

## PATIENTS FORM

ID:

### DEMOGRAPHIC INFORMATION:

Sex:	1) Male <input type="checkbox"/>	2) Female <input type="checkbox"/>
Age (year):	<input type="text"/> <input type="text"/>	
Diabetes History	1) yes <input type="checkbox"/>	2) No <input type="checkbox"/>
Hypertension history	1) yes <input type="checkbox"/>	2) No <input type="checkbox"/>
Hyperlipidemia history	1) yes <input type="checkbox"/>	2) No <input type="checkbox"/>
Smoking history	1) yes <input type="checkbox"/>	2) No <input type="checkbox"/>

# Enter variables

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure
1	sex	Numeric	8	2		None	None	8	Right	Scale
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										

1. Click Variable View
2. Type variable name under Name column (e.g. Sex).  
*NOTE: Variable name can be 64 bytes long, and the first character must be a letter or one of the characters @, #, or \$.*
3. Type: Numeric, string, etc.
4. Label: description of variables.
5. Measure: Nominal, Ordinal, Scale

# Enter variables

The screenshot shows the IBM SPSS Statistics Data Editor interface. The main window displays a variable definition table for a variable named 'sex'. The table has columns for Name, Type, Width, Decimals, Label, Values, Missing, Columns, and Align. The 'sex' variable is defined as Numeric, with a width of 8 and 2 decimal places. The 'Values' column shows 'None' with a dropdown arrow.

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align
1	sex	Numeric	8	2		None	None	8	Right
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									

Two 'Value Labels' dialog boxes are overlaid on the main window. The top dialog box is empty, with 'Value:' and 'Label:' fields and an 'Add' button. The bottom dialog box shows the 'Value:' field set to '2' and the 'Label:' field set to 'female'. A list box below contains the entry '1.00 = "male"'. Both dialog boxes have 'Spelling...', 'Add', 'Change', 'Remove', 'OK', 'Cancel', and 'Help' buttons.



# Enter cases

\*Untitled2 [DataSet1] - IBM SPSS Statistics Data Editor

File Edit View Data Transform Analyze Direct Marketing Graphs Utilities Add-ons Window Help

10 : sex 1.00 Visible: 1 of 1 Variables

	sex	var	var	var	var	var	var	var	var	var	v
1	male										
2	female										
3	male										
4	male										
5	male										
6	male										
7	male										
8	female										
9	female										
10	male										
11											
12											
13											

1. One variables in the data set.  
2. This is: Sex: 1 = male, 2 = female

Under Data View

Data View Variable View

IBM SPSS Statistics Processor is ready Unicode:ON

# PRACTICE



How would you put the following information in to SPSS ??

Sex	Age	Diabetes History	Hypertension history	Hyperlipidemia history	Smoking history
Female	55	Yes	No	Yes	Yes
Male	53	Yes	Yes	Yes	Yes
Female	35	Yes	No	Yes	No
Female	45	No	No	Yes	No
Female	53	No	No	No	Yes
Male	47	Yes	Yes	Yes	Yes
Male	38	Yes	Yes	Yes	Yes
Female	46	No	Yes	No	Yes
Female	36	Yes	No	No	No
Male	51	No	Yes	Yes	Yes

# Data used in the workshop

## Variable:

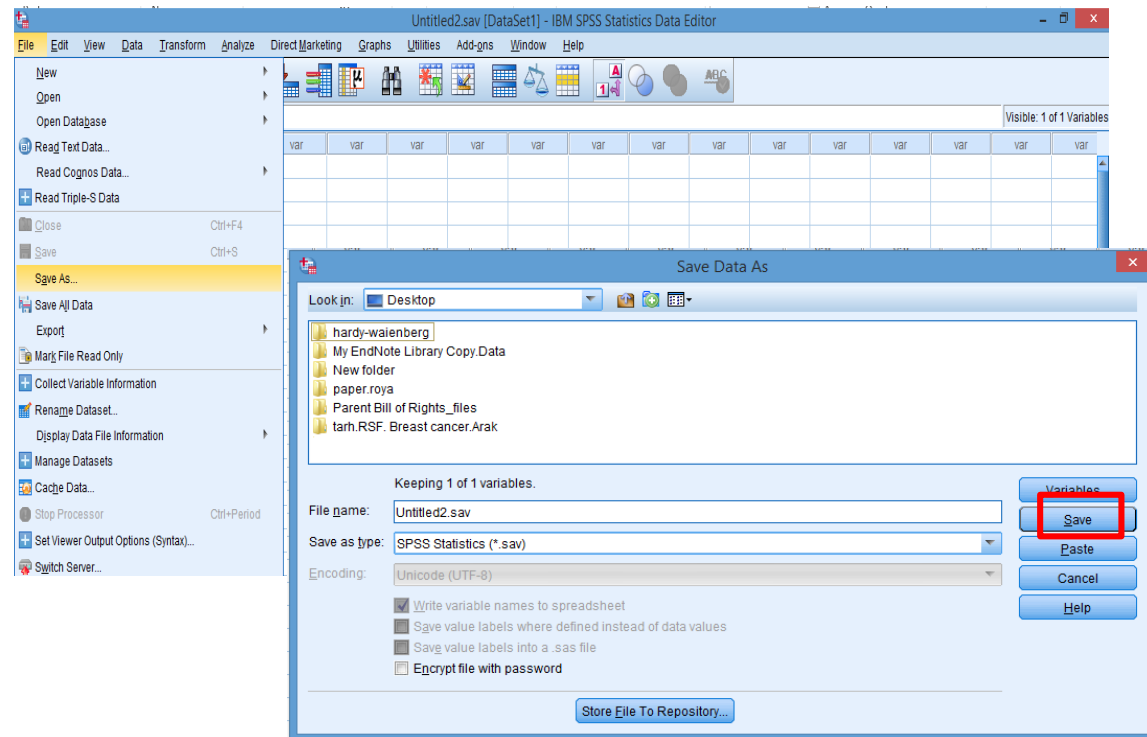
- Sex
- Age
- Diabetes History
- Hypertension history
- Hyperlipidemia history
- Smoking history

	ID	Sex	age	DM	HTN	HLP	HSmok	var	var	var
1	1	Female	55	Yes	No	Yes	Yes			
2	2	Male	53	Yes	Yes	Yes	Yes			
3	3	Female	35	Yes	No	Yes	No			
4	4	Female	45	No	No	Yes	No			
5	5	Female	53	No	No	No	Yes			
6	6	Male	47	Yes	Yes	Yes	Yes			
7	7	Male	38	Yes	Yes	Yes	Yes			
8	8	Female	46	No	Yes	No	Yes			
9	9	Female	36	Yes	No	No	No			
10	10	Male	51	No	Yes	Yes	Yes			
11										
12										
13										

# Saving the file

The file must always be saved in order to save the work that has been done to date:

- File/Save as
- Move to the target directory
- Enter a file name
- Save

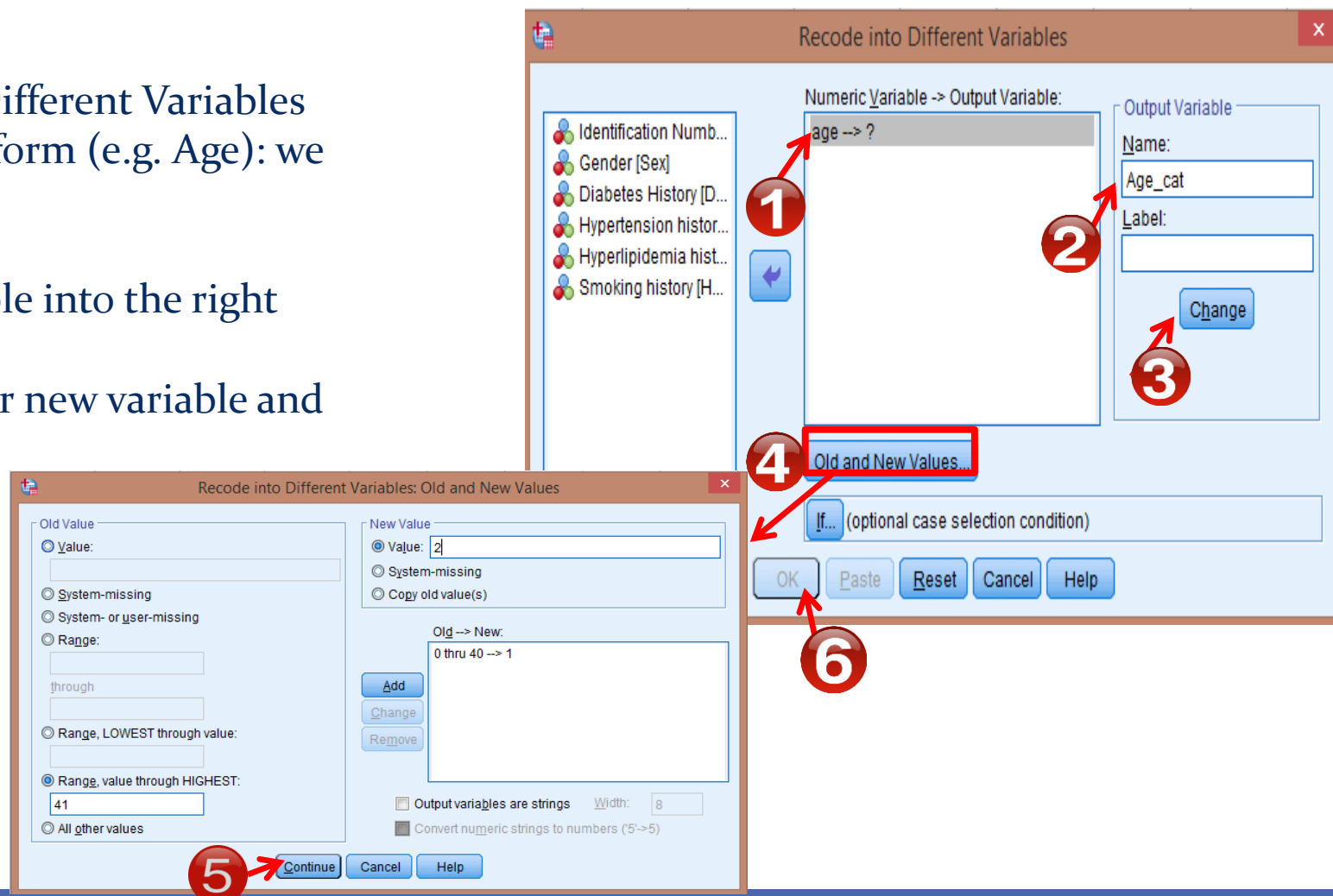


# Descriptive statistics

- Collection
- Organization
- Summarize data
  - Tables
  - Graphs
  - Measures of Central Tendency
  - Index of dispersion

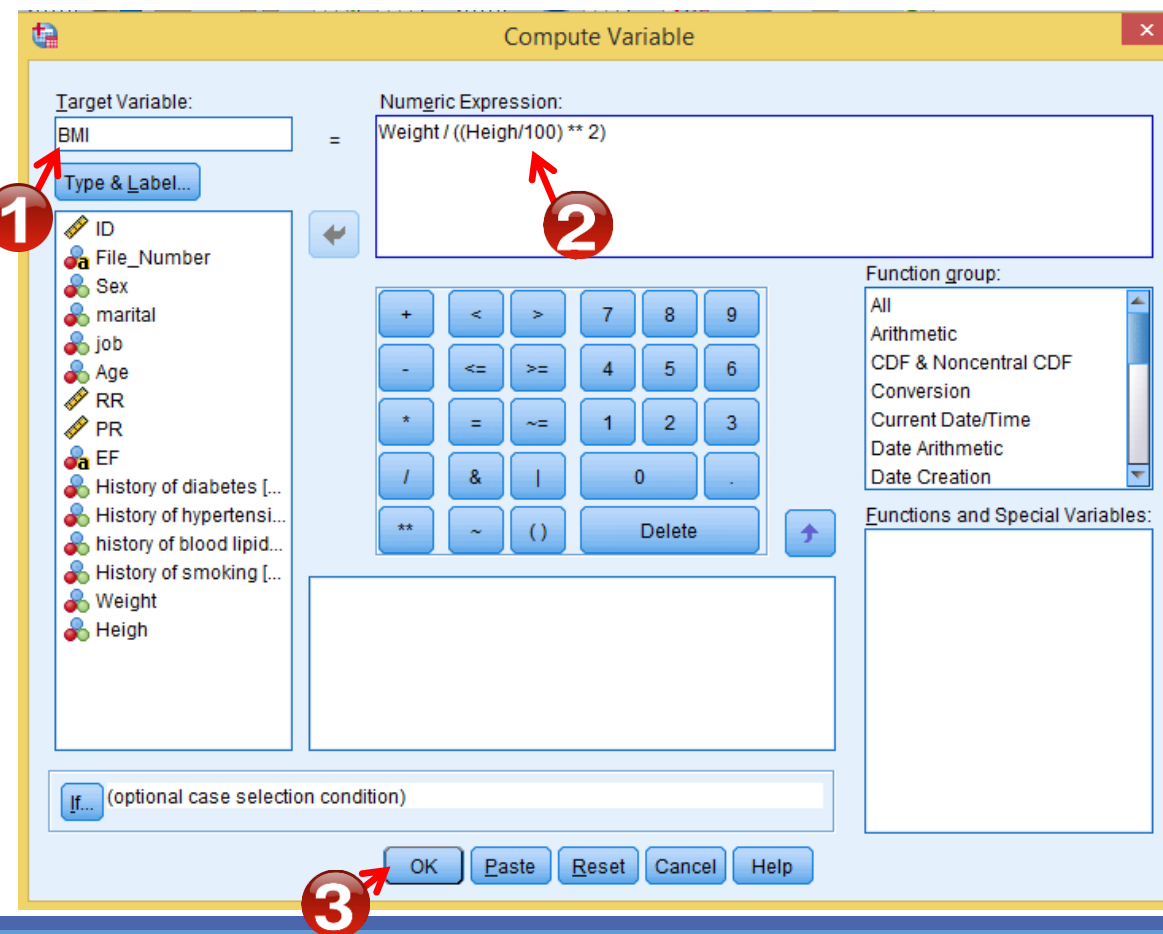
# Variable transformation

1. Select Transform  $\longrightarrow$  Recode into Different Variables
2. Select variable that you want to transform (e.g. Age): we want  
1:  $= < 40$  and 2:  $> 41$
3. Click Arrow button to put your variable into the right window
4. Under Output Variable: type name for new variable and label, then click Change
5. Click Old and New Values



# Variable transformation

- Compute variable
- Example 1. Create a new variable: BMI
- Use Weight, Height
- Go to Transform  $\longrightarrow$  Compute Variable **1**



# Sort and select cases

- Sort cases

- Sort cases by variables: Data  $\longrightarrow$  Sort Cases
- You can use Sort Cases to find missing.

The screenshot shows the IBM SPSS Statistics Data Editor window with the following data table:

	ID	Sex	age	DM	HTN	HLP	HSmok	Age_cat	var	var	var	var
1	1	Female	55	Yes	No	Yes	Yes	2.00				
2	2	Male	53	Yes	Y	Y	Y	0.00				
3	3	Female	35	Yes								
4	4	Female	45	No								
5	5	Female	53	No								
6	6	Male	47	Yes								
7	7	Male	38	Yes								
8	8	Female	46	No								
9	9	Female	36	Yes								
10	10	Male	51	No								
11												
12												
13												
14												
15												
16												
17												
18												
19												

The Sort Cases dialog box is open, showing the following options:

- Sort by: Identification Num...
- Sort Order:  Ascending,  Descending
- Save Sorted Data:  Save file with sorted data,  Create an index
- Buttons: OK, Paste, Reset, Cancel, Help



# Sort and select cases

- Select cases
  - Example 1. Select Females for analysis.
  - Go to Data → Select Cases
  - Under Select: check the second one
  - Click If button

\*Data Entry.sav [DataSet4] - IBM SPSS Statistics Data Editor

	ID	Sex	age	DM	HTN	HLP	HSmok	Age_cat	var	var	var
1	1	Female	55	Yes	No	Yes	Yes	2.00			
2	2	Male	53	Yes							
3	3	Female	35	Yes							
4	4	Female	45	No							
5	5	Female	53	No							
6	6	Male	47	Yes							
7	7	Male	38	Yes							
8	8	Female	46	No							
9	9	Female	36	Yes							

Select Cases

Select

All cases

If condition is satisfied

Random sample of cases

Based on time or case range

Use filter variable:

Output

Filter out unselected cases

Copy selected cases to a new dataset

Dataset name: \_\_\_\_\_

Delete unselected cases

not filter cases

OK Paste Reset Cancel Help

Select Cases: If

Sex=1

Function group:

All

Arithmetic

CDF & Noncentral CDF

Conversion

Current Date/Time

Date Arithmetic

Date Creation

Functions and Special Variables:

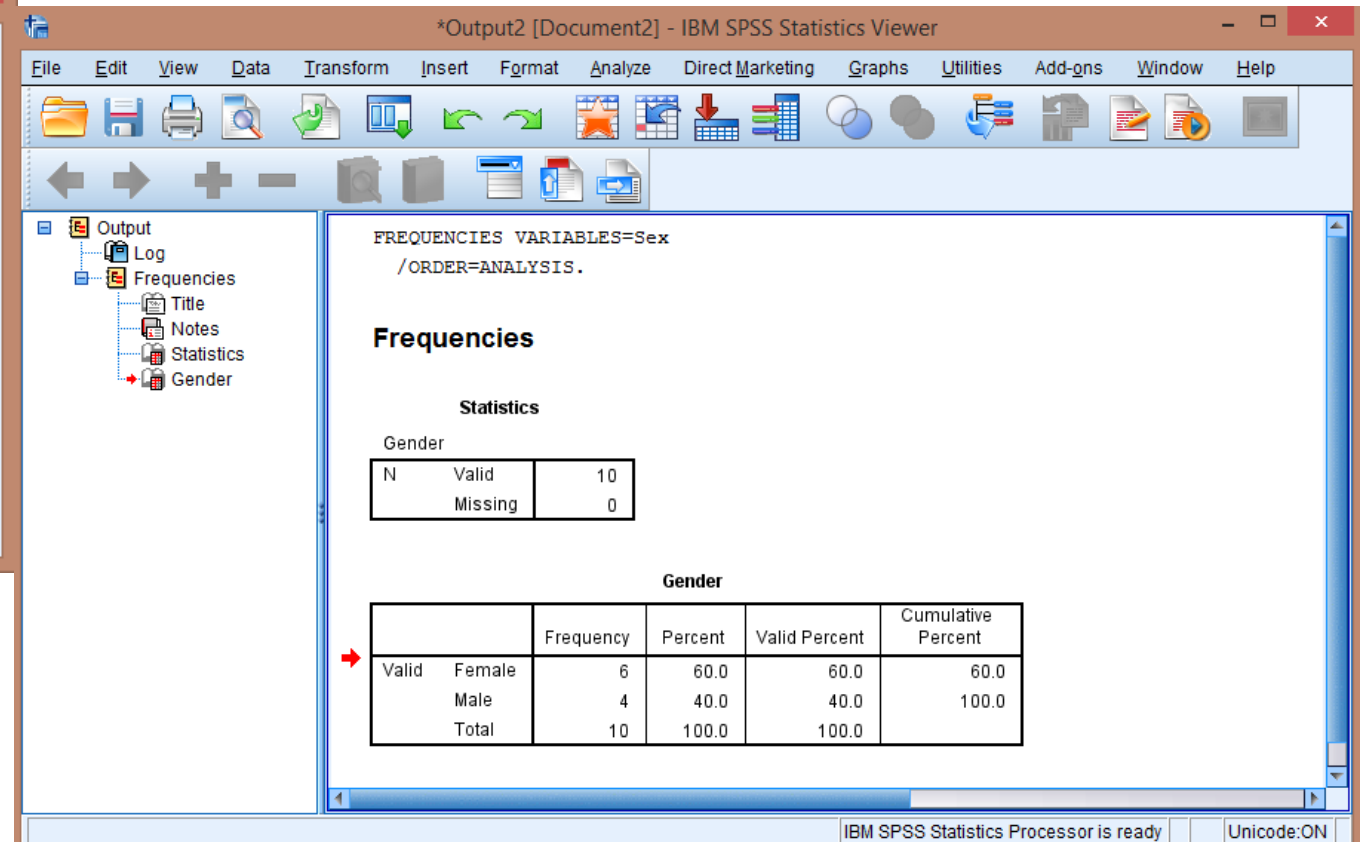
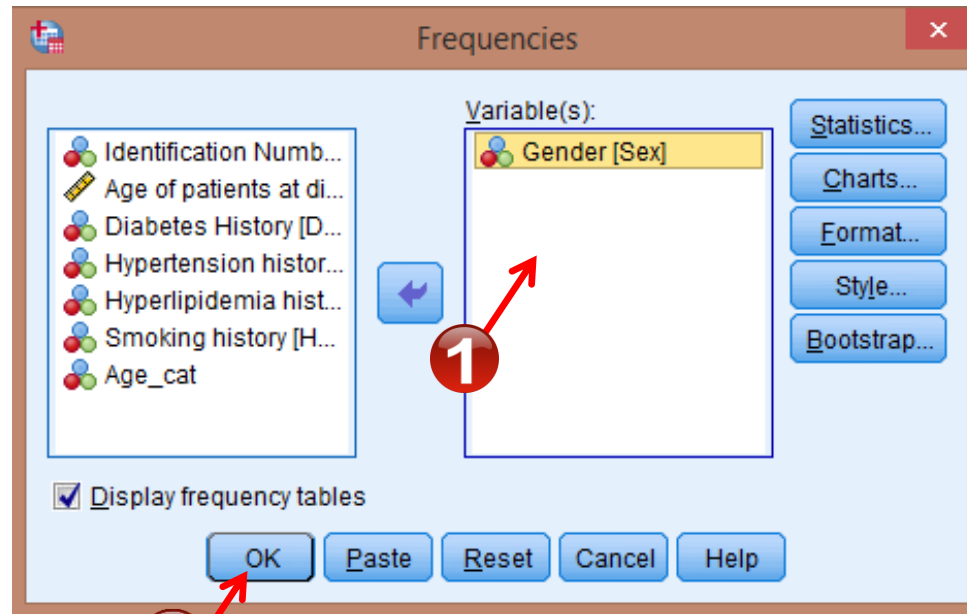
Continue Cancel Help

# Descriptive statistics

- Collection
- Organization
- Summarize data
  - Tables
  - Graphs
  - Measures of Central Tendency
  - Index of dispersion

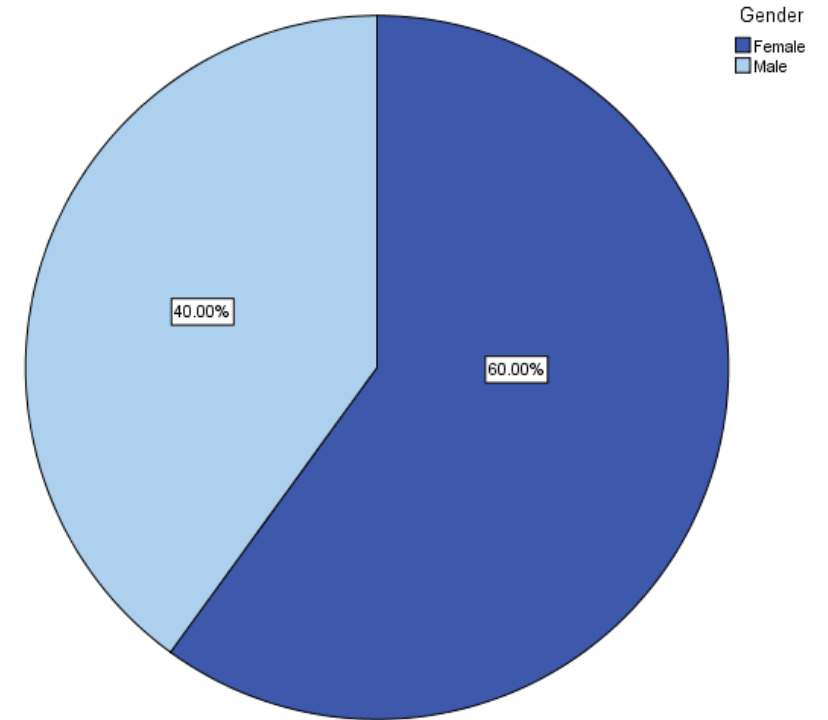
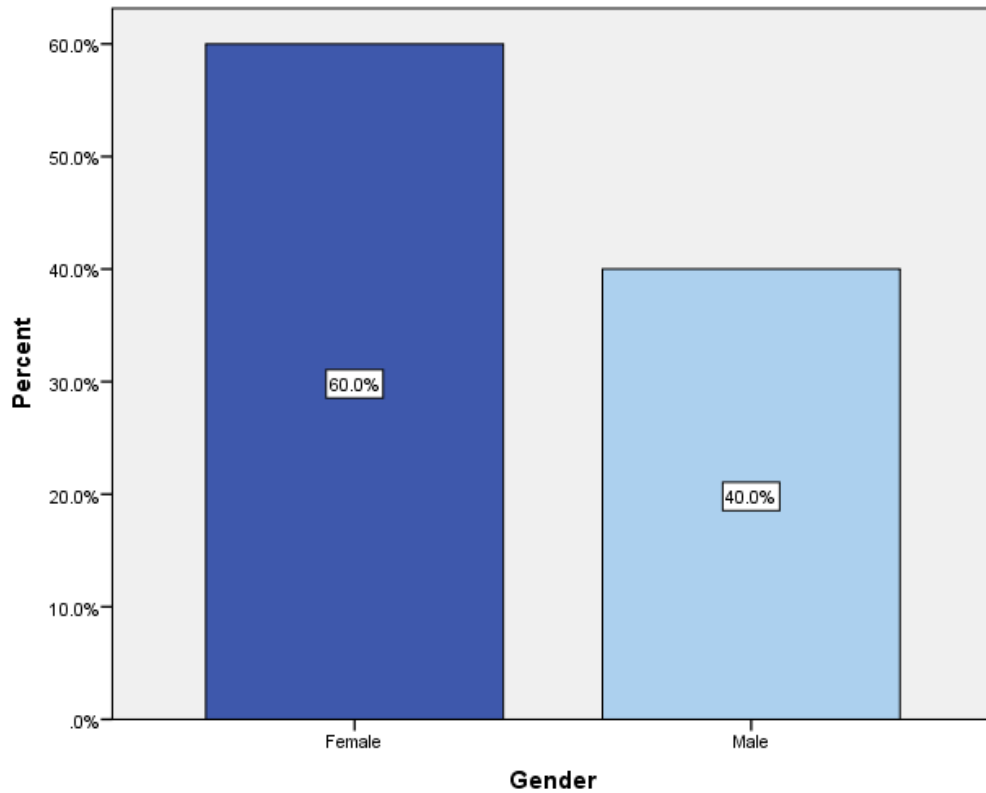
# Descriptive statistics: Tables

 Analyze → Descriptive statistics → Frequency



# Descriptive statistics: Graphs

$\sum_{+}^{\alpha}$  Graphs  $\longrightarrow$  Legacy Dialogs  $\longrightarrow$  Bar, Pie, ...



# Descriptive statistics: Measures of Central Tendency & Index of dispersion

$\Sigma \alpha$  Analyze → Descriptive statistics → Descriptive

1

2

3

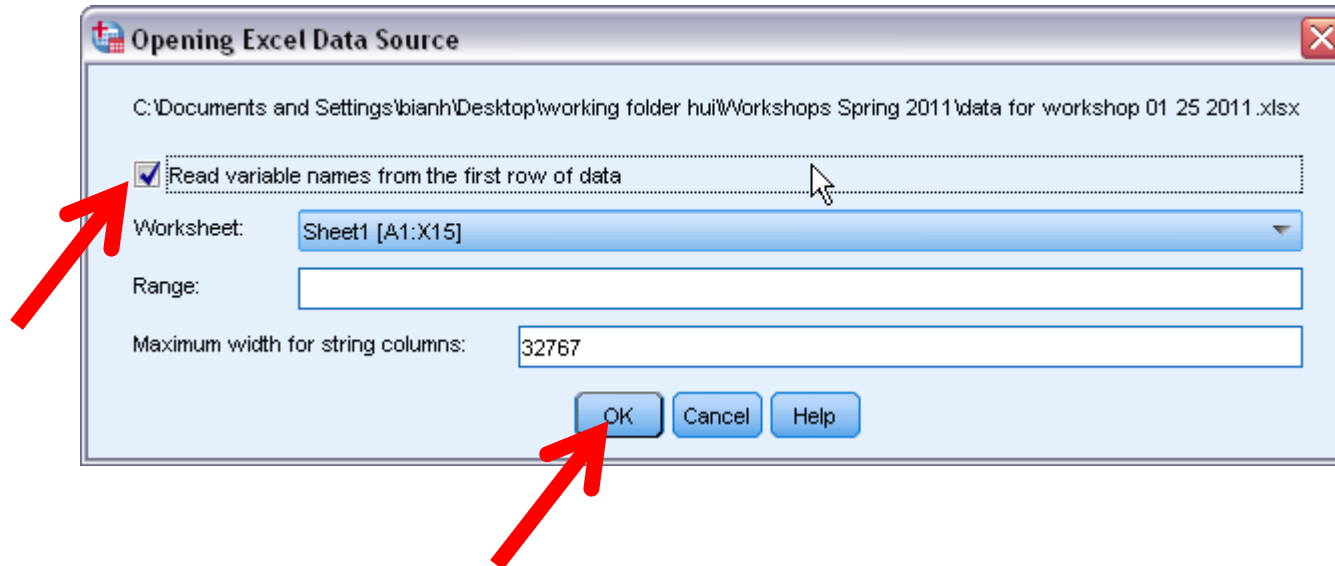
→ Descriptives

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Age of patients at diagnosis	10	35	55	45.90	7.385
Valid N (listwise)	10				

# Import data from Excel

- Select File → Open → Data
- Choose **Excel** as file type
- Select the file you want to import
- Then click Open



# Inferential statistics

- ❑ Estimating population parameter from sample data
- ❑ Hypothesis Testing
- ❑ Statistical Methods of Analysis
  - Parametric
  - Non-Parametric

# Chi-Square Statistic (Pearson's chi-square test)

- We perform this test when we want to determine whether there is an association between categorical variables.
- Assumptions
  1. Independent observations
  2. For a 2 by 2 table, all expected frequencies  $> 5$ .  
For a larger table, no more than 20% of all cells may have an expected frequency  $< 5$  and all expected frequencies  $> 1$ .



Null hypothesis: (Variable 1) is independent of (Variable 2).  
(Variable 1) is not associated with (Variable 2).

If the p-value is **less than** alpha, you **reject** the null hypothesis.



# Chi-Square Statistic (Pearson's chi-square test)

$\sum \alpha$  Analyze → Descriptive Statistics → Crosstabs

Smoke	MI	Freq
1	1	1413
1	2	1250
2	1	56
2	2	219

Crosstabs

Row(s):  
Smoke

Column(s):  
MI

Exact...  
Statistics...  
Cells...  
Format...  
Style...  
Bootstrap...

Previous Next

Display layer variables in table layers

Display clustered bar charts  
Suppress tables

OK Paste Reset Cancel Help

Crosstabs: Statistics

Chi-square  Correlations

Nominal

Contingency coefficient  
 Phi and Cramer's V  
 Lambda  
 Uncertainty coefficient

Ordinal

Gamma  
 Somers' d  
 Kendall's tau-b  
 Kendall's tau-c

Nominal by Interval

Eta

Kappa  
 Risk  
 McNemar

Cochran's and Mantel-Haenszel statistics  
Test common odds ratio equals: 1

Continue Cancel Help

# Chi-Square Statistic (Pearson's chi-square test)

Smoke \* MI Crosstabulation

Count

		MI		Total
		Yes	No	
Smoke	Yes	1413	1250	2663
	No	56	219	275
Total		1469	1469	2938

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	106.592 <sup>a</sup>	1	.000		
Continuity Correction <sup>b</sup>	105.288	1	.000		
Likelihood Ratio	113.243	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	106.555	1	.000		
N of Valid Cases	2938				

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 137.50.

b. Computed only for a 2x2 table

# Independent Sample T-Test (Independent T-Test or Two-Sample T-Test )

- We perform this test when we want to compare the **mean** of **two different samples**.
- Assumptions
  1. Independent observations
  2. Normality (Kolmogorov–Smirnov test/ Shapiro–Wilk test)
  3. Homogeneity of variance (Levene's test )



**Null hypothesis:** The two population means are equal.

The difference between the two population means is equal to 0.

If the p-value is **less than** alpha, you **reject** the null hypothesis.

# Normality test

- Kolmogorov–Smirnov test

 Analyze → Nonparametric Tests → Legacy Dialogs → 1-Sample K-S

- Shapiro–Wilk test

 Analyze → Descriptive Statistics → Explore → Plots → Normality plots with tests



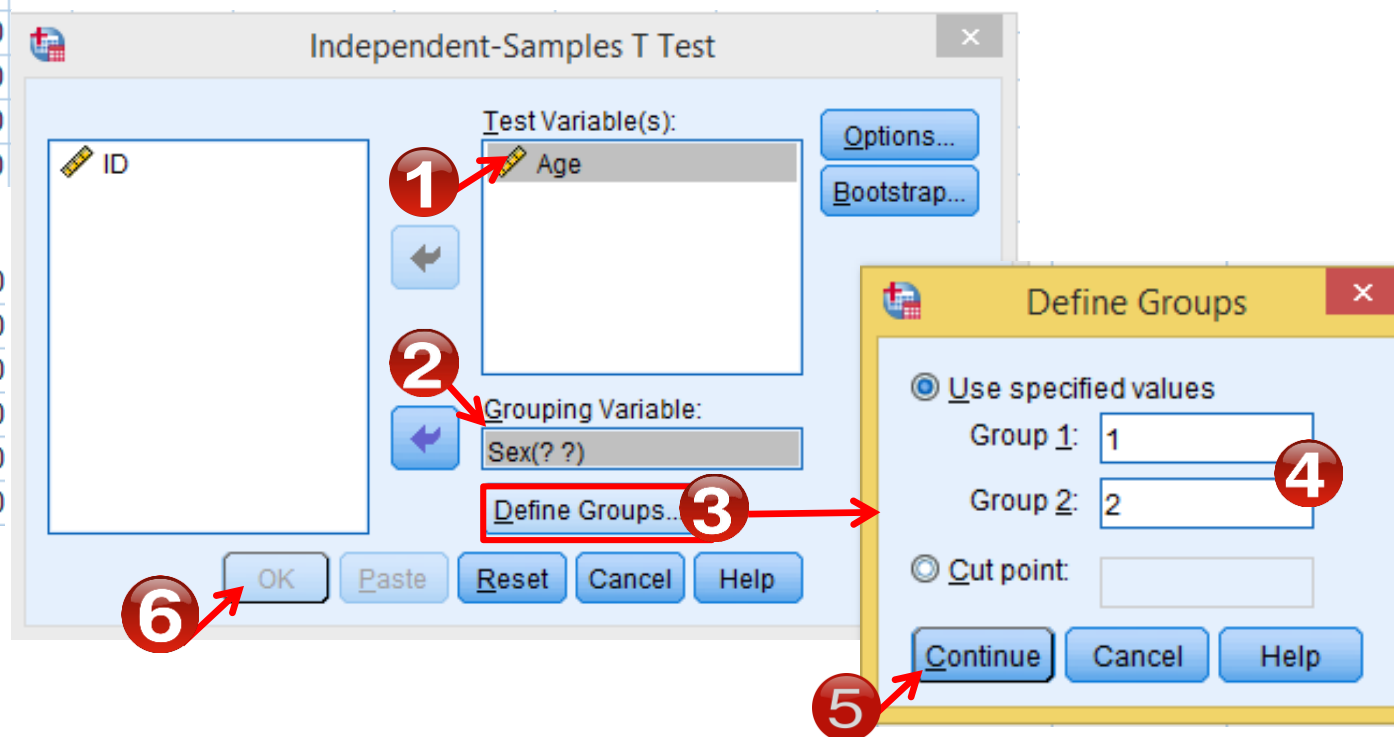
Null hypothesis: The data is normally distributed

If the p-value is **less than** alpha, you **reject** the null hypothesis.

# Independent Sample T-Test (Independent T-Test or Two-Sample T-Test)

 Analyze → Compare Means → Independent-Samples T-Test

ID	Sex	Age
1	male	44.00
2	male	80.00
3	male	79.00
4	male	70.00
5	male	73.00
⋮		
35	female	79.00
36	female	80.00
37	female	50.00
38	female	76.00
39	female	64.00
40	female	64.00



The screenshot shows the 'Independent-Samples T Test' dialog box in SPSS. The 'Test Variable(s):' list contains 'Age' (annotated with 1). The 'Grouping Variable:' list contains 'Sex(??)' (annotated with 2). The 'Define Groups...' button is highlighted with a red box and annotated with 3. The 'Define Groups' sub-dialog box is open, showing 'Use specified values' selected, with 'Group 1:' set to 1 (annotated with 4) and 'Group 2:' set to 2. The 'Continue' button in the sub-dialog is annotated with 5. The 'OK' button in the main dialog is annotated with 6.

# Independent Sample T-Test (Independent T-Test or Two-Sample T-Test)

## → Assumptions (Normality)

Sex = male

One-Sample Kolmogorov-Smirnov Test<sup>a</sup>

		Age
N		20
Normal Parameters <sup>b,c</sup>	Mean	68.6000
	Std. Deviation	13.02791
Most Extreme Differences	Absolute	.103
	Positive	.052
	Negative	-.103
Test Statistic		.103
Asymp. Sig. (2-tailed)		.200 <sup>d,e</sup>

## → T-Test

Group Statistics

	Sex	N	Mean	Std. Deviation	Std. Error Mean
Age	male	20	68.6000	13.02791	2.91313
	female	20	71.9000	10.48257	2.34397

## → Assumptions (Homogeneity of variance)

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Age	Equal variances assumed	1.093	.302	-.883	38	.383	-3.30000	3.73905	-10.86932	4.26932
	Equal variances not assumed			-.883	36.336	.383	-3.30000	3.73905	-10.88072	4.28072

Sex = female

One-Sample Kolmogorov-Smirnov Test<sup>a</sup>

		Age
N		20
Normal Parameters <sup>b,c</sup>	Mean	71.9000
	Std. Deviation	10.48257
Most Extreme Differences	Absolute	.130
	Positive	.130
	Negative	-.102
Test Statistic		.130
Asymp. Sig. (2-tailed)		.200 <sup>d,e</sup>

# Example

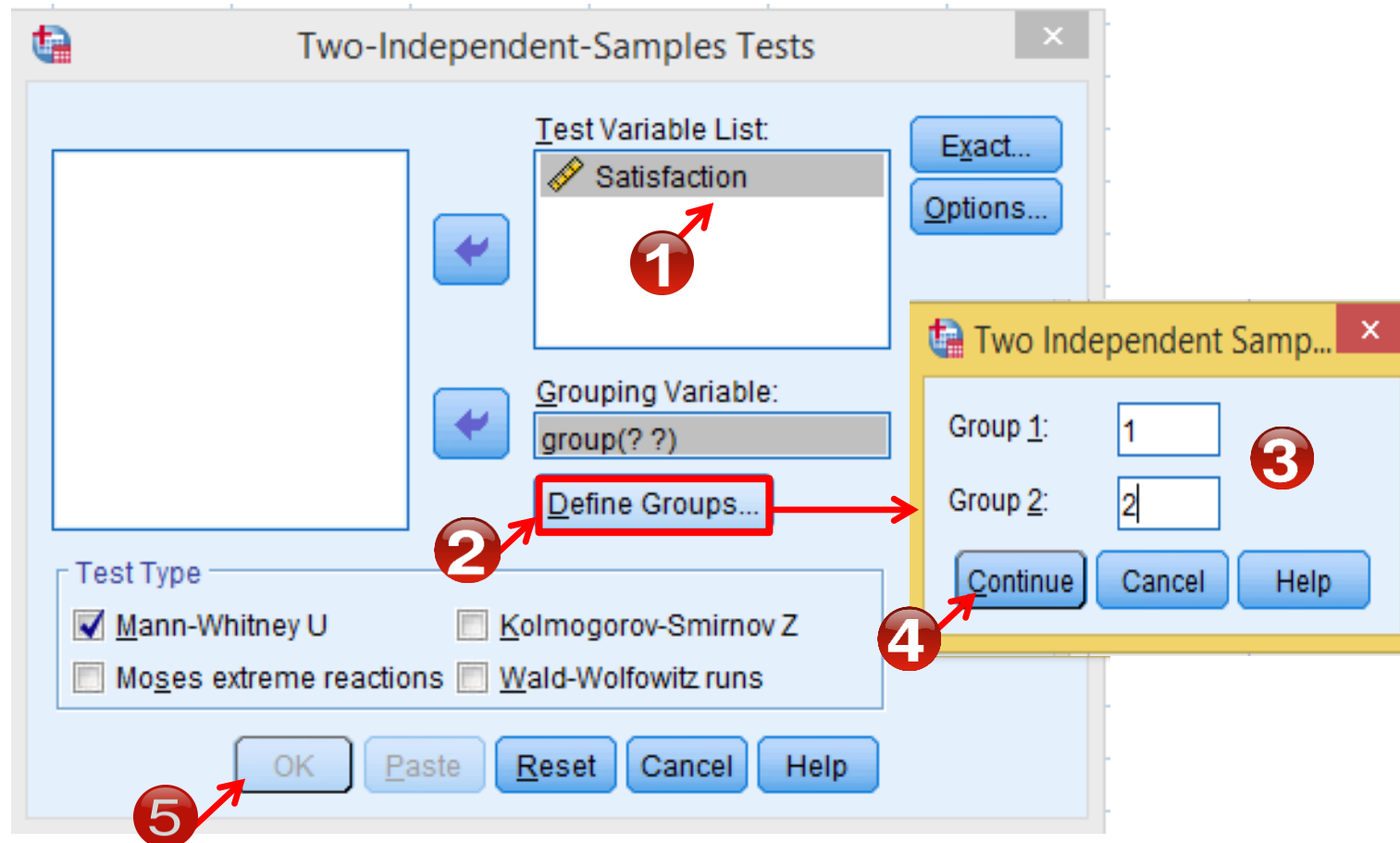
- The Effect of **Nursing Consultation** on **Satisfaction** of Patient's Families at the Cardiac Surgical Intensive Care Unit.

group	Satisfaction	group	Satisfaction
Control	2.29	Case	4.33
Control	2.43	Case	4.05
Control	2.52	Case	4.19
Control	2.52	Case	4.14
Control	2.33	Case	4.43
Control	2.62	Case	4.38
Control	2.33	Case	4.57
Control	2.48	Case	4.38
Control	2.67	Case	4.38
Control	2.38	Case	4.38
Control	2.43	Case	4.29
Control	2.38	Case	4.05
Control	2.52	Case	4.24
Control	2.57	Case	4.38
Control	4.56		
Control	4.30		

$$\begin{cases} H_0: \mu_1 = \mu_2 \\ H_1: \mu_1 \neq \mu_2 \end{cases}$$

# MannWhitney test

$\sum \alpha$  Analyze → Nonparametric Tests → Legacy Dialogs → Two Independent Samples test



## Mann-Whitney Test Test Statistics<sup>a</sup>

	Satisfaction
Mann-Whitney U	18.000
Wilcoxon W	154.000
Z	-3.780
Asymp. Sig. (2-tailed)	.000
Exact Sig. [2*(1-tailed Sig.)]	.000 <sup>b</sup>



# One-Way ANOVA (Analysis of Variance)

- We perform this test when we want to compare the **mean** of **more than two independent groups**.
- Assumptions
  1. Independent observations
  2. Normality Normality (Kolmogorov–Smirnov test/ Shapiro–Wilk test)
  3. Homogeneity of variance (Levene's test )



Null hypothesis: All population means are equal.

If the p-value is **less than** alpha, you **reject** the null hypothesis.

# One-Way ANOVA (Analysis of Variance)

$\sum \alpha$  Analyze → Compare Means → One-Way ANOVA

- Investigating the Factor of Biological Materials on Cell Diameter Size

Substance	G_Diameter	Substance	G_Diameter	Substance	G_Diameter
Esterogen	43.00	Progestron	35.00	Control	20.50
Esterogen	45.00	Progestron	33.50	Control	17.50
Esterogen	44.00	Progestron	29.50	Control	19.50
Esterogen	42.00	Progestron	35.00	Control	23.00
Esterogen	44.00	Progestron	41.00	Control	23.00
Esterogen	41.00	Progestron	35.50	Control	25.50
Esterogen	46.00	Progestron	41.00	Control	16.00
Esterogen	43.00	Progestron	40.50	Control	19.50
Esterogen	46.00	Progestron	41.00	Control	26.00
Esterogen	41.00	Progestron	40.50	Control	23.50
Esterogen	46.00	Progestron	38.50	Control	21.50
Esterogen	42.50	Progestron	42.00	Control	21.00

The image shows two overlapping dialog boxes from SPSS. The main dialog is 'One-Way ANOVA' and the sub-dialog is 'One-Way ANOVA: Options'. Red circles with numbers 1 through 6 point to specific elements:

- 1**: Points to the 'Dependent List' field containing 'G\_Diameter'.
- 2**: Points to the 'Factor' field containing 'Substance'.
- 3**: Points to the 'Options...' button in the main dialog.
- 4**: Points to the 'Homogeneity of variance test' checkbox, which is checked in the options dialog.
- 5**: Points to the 'Continue' button in the options dialog.
- 6**: Points to the 'OK' button in the main dialog.

# One-Way ANOVA (Analysis of Variance)

## → Assumptions (Normality)

### Substance = Esterogen

#### One-Sample Kolmogorov-Smirnov Test<sup>a</sup>

		G_Diameter
N		12
Normal Parameters <sup>b,c</sup>	Mean	43.6250
	Std. Deviation	1.84791
Most Extreme Differences	Absolute	.151
	Positive	.132
	Negative	-.151
Test Statistic		.151
Asymp. Sig. (2-tailed)		.200 <sup>d,e</sup>

### Substance = Progesteron

#### One-Sample Kolmogorov-Smirnov Test<sup>a</sup>

		G_Diameter
N		12
Normal Parameters <sup>b,c</sup>	Mean	37.7500
	Std. Deviation	3.95141
Most Extreme Differences	Absolute	.257
	Positive	.141
	Negative	-.257
Test Statistic		.257
Asymp. Sig. (2-tailed)		.028 <sup>d</sup>

### Substance = Control

#### One-Sample Kolmogorov-Smirnov Test<sup>a</sup>

		G_Diameter
N		12
Normal Parameters <sup>b,c</sup>	Mean	21.3750
	Std. Deviation	3.01606
Most Extreme Differences	Absolute	.122
	Positive	.074
	Negative	-.122
Test Statistic		.122
Asymp. Sig. (2-tailed)		.200 <sup>d,e</sup>

## → Assumptions (Homogeneity of variance)

### Test of Homogeneity of Variances

G_Diameter			
Levene Statistic	df1	df2	Sig.
4.363	2	33	.021

### ANOVA

G_Diameter					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3190.875	2	1595.438	170.180	.000
Within Groups	309.375	33	9.375		
Total	3500.250	35			

# One-Way ANOVA (Analysis of Variance)

## ANOVA

G\_Diameter

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3190.875	2	1595.438	170.180	.000
Within Groups	309.375	33	9.375		
Total	3500.250	35			

The screenshot shows the SPSS One-Way ANOVA dialog box with 'G\_Diameter' in the Dependent List. The 'Post Hoc...' button is highlighted with a red circle and arrow labeled '1'. The 'Post Hoc Multiple Comparisons' sub-dialog box is open, showing 'Tukey' selected under 'Equal Variances Assumed' with a red circle and arrow labeled '2'. The 'Continue' button in the sub-dialog is highlighted with a red circle and arrow labeled '3'. The 'OK' button in the main dialog is highlighted with a red circle and arrow labeled '4'.

## Post Hoc Tests

### Multiple Comparisons

Dependent Variable: G\_Diameter

Tukey HSD

(I) Substance	(J) Substance	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Esterogen	Progestron	5.87500*	1.25000	.000	2.8078	8.9422
	Control	22.25000*	1.25000	.000	19.1828	25.3172
Progestron	Esterogen	-5.87500*	1.25000	.000	-8.9422	-2.8078
	Control	16.37500*	1.25000	.000	13.3078	19.4422
Control	Esterogen	-22.25000*	1.25000	.000	-25.3172	-19.1828
	Progestron	-16.37500*	1.25000	.000	-19.4422	-13.3078

\*. The mean difference is significant at the 0.05 level.

# Kruskal-Wallis Test

$\sum \alpha$  Analyze → Nonparametric Tests → Legacy Dialogs → K Independent Samples test

Tests for Several Independent Samples

Test Variable List:  
G\_Diameter

Grouping Variable:  
Substance(??)

Define Range...

Test Type:  
 Kruskal-Wallis H  Median  
 Jonckheere-Terpstra

OK Paste Reset Cancel Help

Several Independent Sa...

Range for Grouping Variable  
Minimum: 1  
Maximum: 3

Continue Cancel Help

## Kruskal-Wallis Test

Test Statistics<sup>a,b</sup>

	G_Diameter
Chi-Square	28.633
df	2
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable:  
Substance

# Paired sample t-test (Dependent T-Test)

- We perform this test when we want to compare **two means** that are from the **same** individual, object, or related units.
- Assumptions
  1. Independent observations
  2. Normality (Kolmogorov–Smirnov test/ Shapiro–Wilk test)



Null hypothesis: The paired population means are equal.

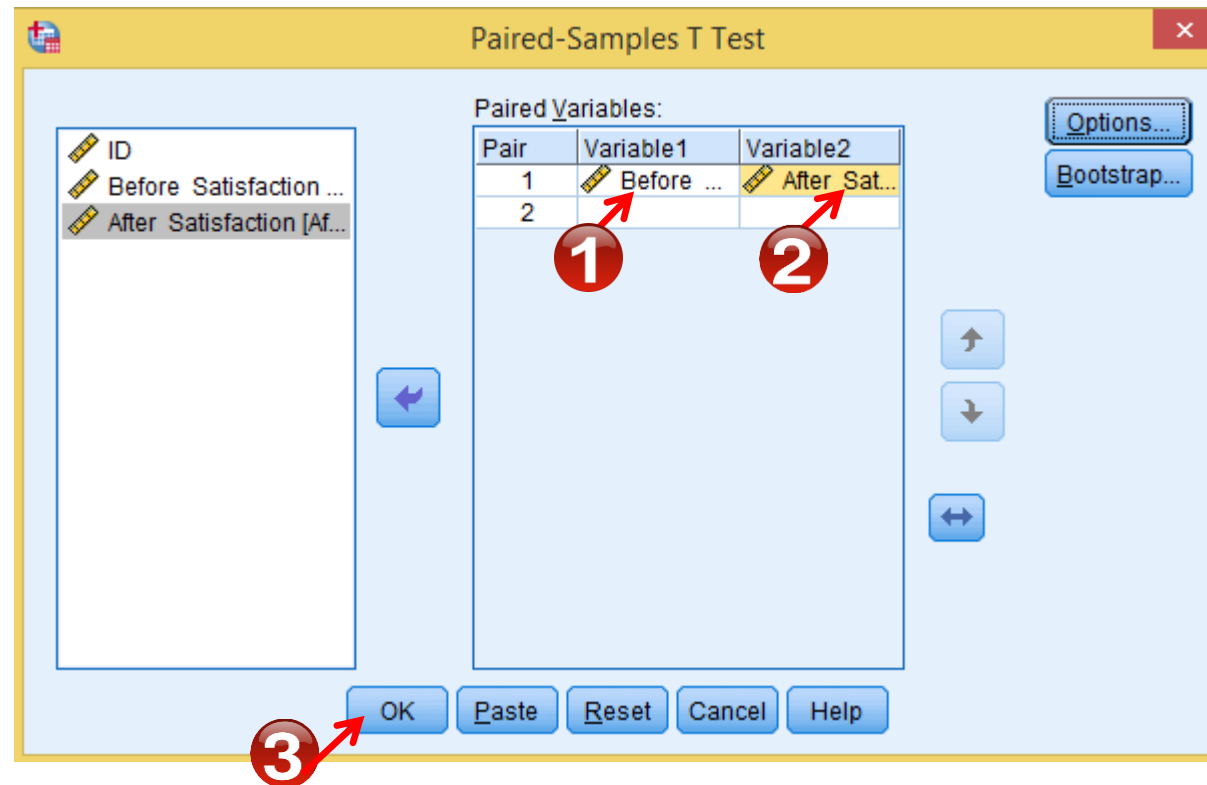
The difference between the paired population means is equal to 0.

If the p-value is **less than** alpha, you **reject** the null hypothesis.

# Paired sample T-Test(Dependent T-Test)

$\sum \alpha$  Analyze → Compare Means → Paired Samples T-Test

ID	Before	After
1	2.29	4.33
2	2.43	4.05
3	2.52	4.19
4	2.52	4.14
5	2.33	4.43
6	2.62	4.38
7	2.33	4.57
8	2.48	4.38
9	2.67	4.38
10	2.38	4.29
11	2.43	4.05
12	2.38	4.24
13	2.52	4.38
14	2.57	4.29
15	4.56	4.05
16	4.30	4.24



# Paired sample t-test (Dependent T-Test)

## → Assumptions (Normality)

One-Sample Kolmogorov-Smirnov Test

		Before Satisfaction	After Satisfaction
N		16	16
Normal Parameters <sup>a,b</sup>	Mean	2.7085	4.2738
	Std. Deviation	.68202	.15109
Most Extreme Differences	Absolute	.399	.136
	Positive	.399	.120
	Negative	-.268	-.136
Test Statistic		.399	.136
Asymp. Sig. (2-tailed)		.000 <sup>c</sup>	.200 <sup>c,d</sup>

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Before Satisfaction	2.7085	16	.68202	.17051
	After Satisfaction	4.2738	16	.15109	.03777

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Before Satisfaction & After Satisfaction	16	-.360	.170

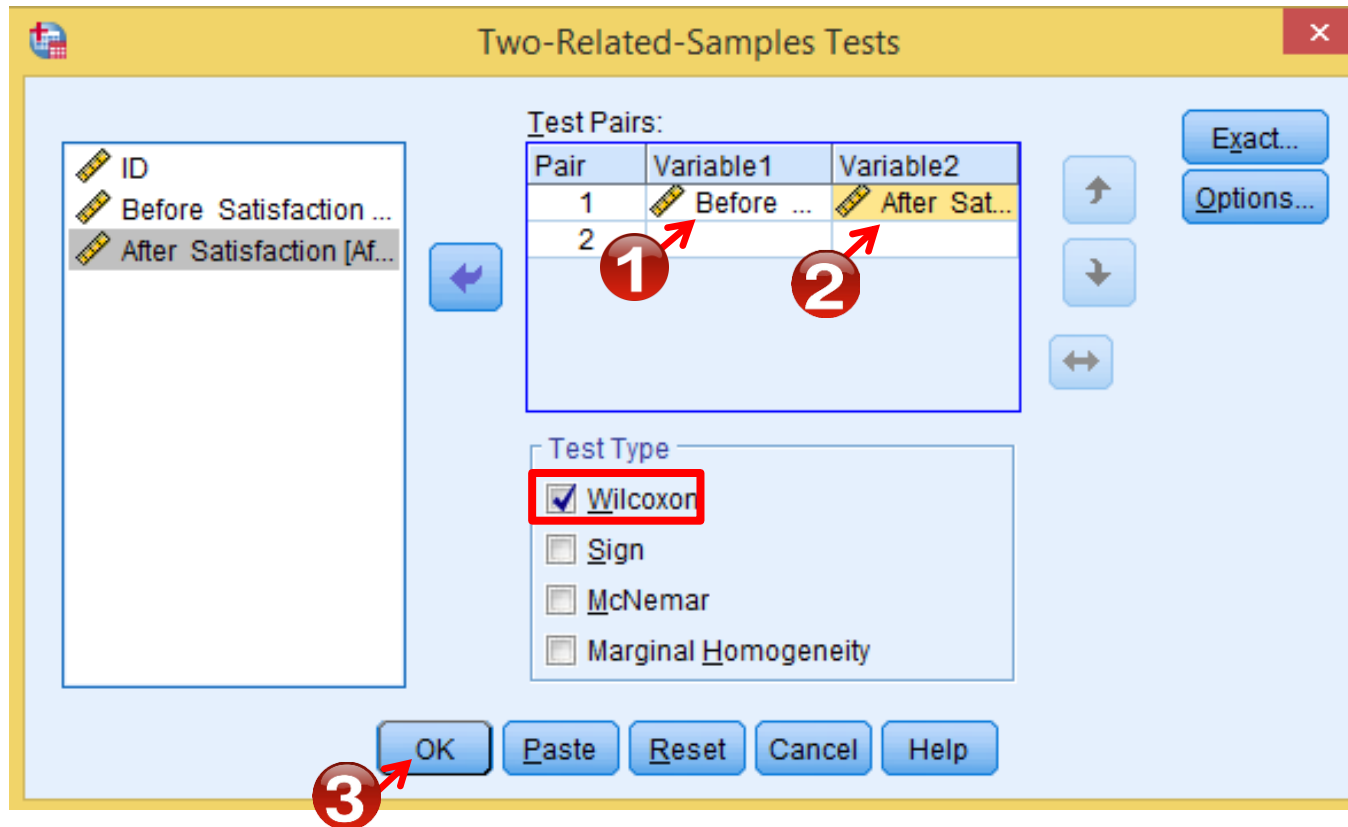
Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Before Satisfaction - After Satisfaction	-1.56530	.74982	.18746	-1.96485	-1.16575	-8.350	15	.000



# Wilcoxon test

$\sum \alpha$  Analyze → Nonparametric Tests → Legacy Dialogs → Two Related Samples test



Test Statistics<sup>a</sup>

	After Satisfaction - Before Satisfaction
Z	-3.365 <sup>b</sup>
Asymp. Sig. (2-tailed)	.001

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

# Statistical Methods of Analysis

Variable	Statistics	Comparison	Test
Nominal	Proportion (P)	2 groups	Fisher's exact test, Chi <sup>2</sup> test
	Proportion (P)	>2 groups	Chi <sup>2</sup> test
Ordinal	Proportion (P)	2 groups	Mann-Whitney
	Proportion (P)	>2 groups	Kruskal-Wallis test
	Proportion (P)	2 groups (paired)	Wilcoxon
Numerical	Mean ( $\mu$ )	2 groups	<i>t</i> -test
	Mean ( $\mu$ )	>2 groups	ANOVA
	Mean ( $\mu$ )	2 groups (paired)	Paired <i>t</i> -test

